(12) UK Patent Application (19) GB (11) 2 167 060 A

(43) Application published 21 May 1986

(21) Application No 8527931

(22) Date of filing 13 Nov 1985

(30) Priority data

(31) 210195 (32) 13 Nov 1984 (33) NZ

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(51) INT CL[4]
C04B 14/38

(52) Domestic classification
C1J 10 14 17 4 9 X

(56) Documents cited
GB A 2093013
GB 1519576
GB 1121266
GB 1093206
GB 1031476
WO A1 85/04391

(58) Field of search
C1J
C3N

(54) Fire resistant material

(57) The present invention relates to a fire resistant material and constructions including fire resistant material. The fire resistant material includes one or more synthetic mineral fibres (e.g. glass wool, rock wool, slag wool, or basalt wool); one or more synthetic clays and one or more binders. The one or more clays are selected to provide an endothermic reaction in the fire resistant material, at temperatures within the range of approximately 400°C to 650°C, when the material is exposed to fire and/or extreme heat.

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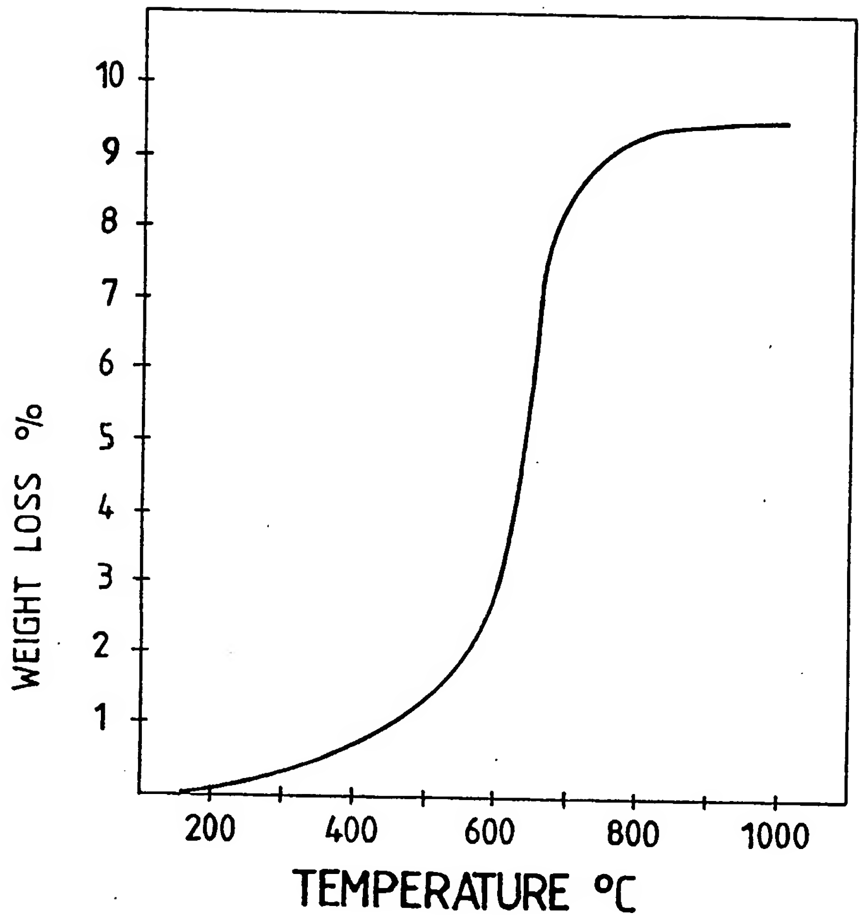

FIGURE 1.

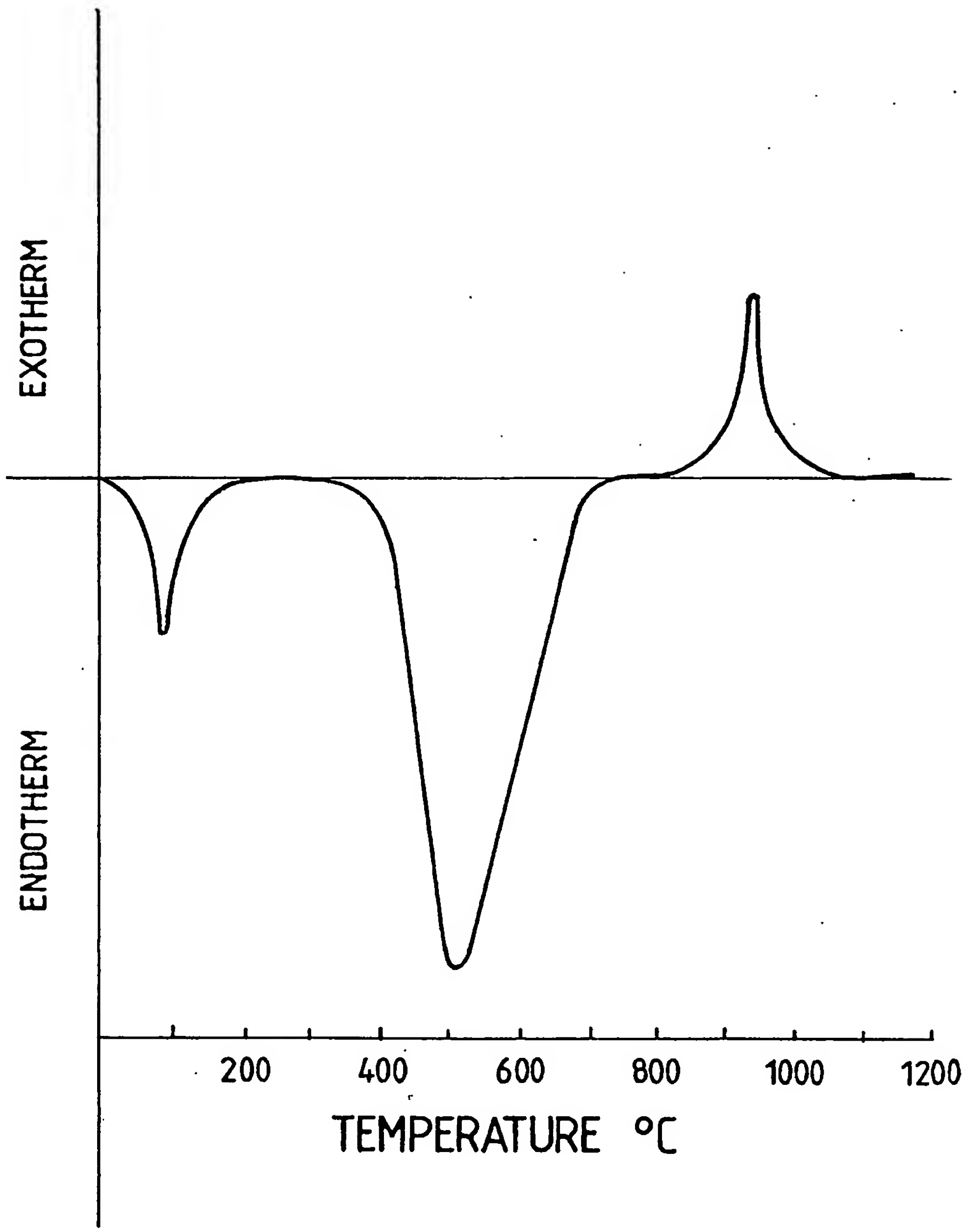

FIGURE 2.

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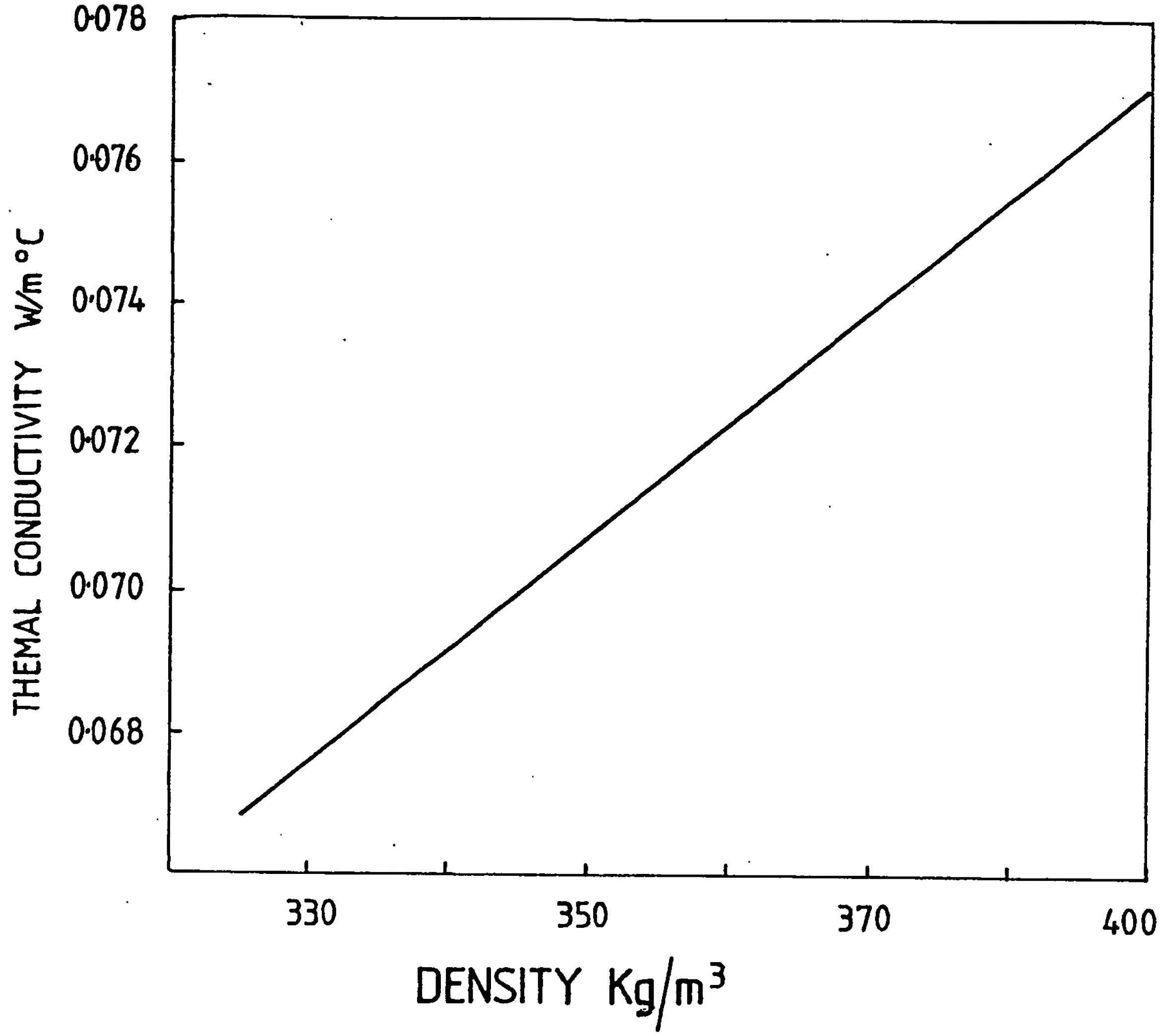

FIGURE 3.

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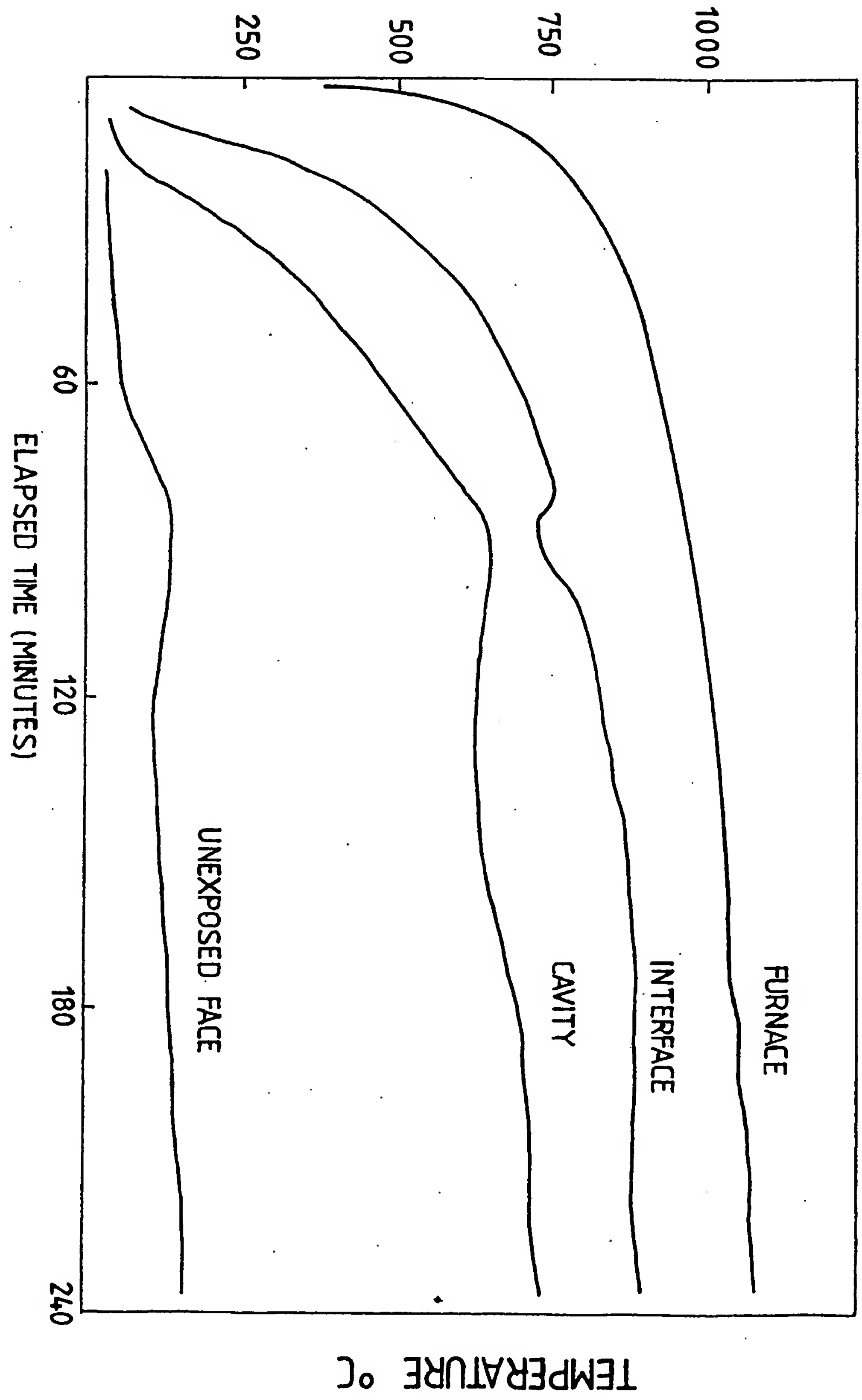

FIGURE 4.

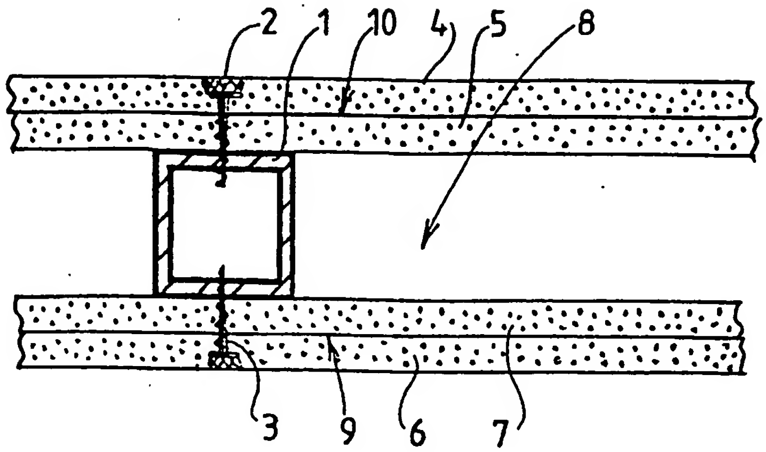

FIGURE 5.

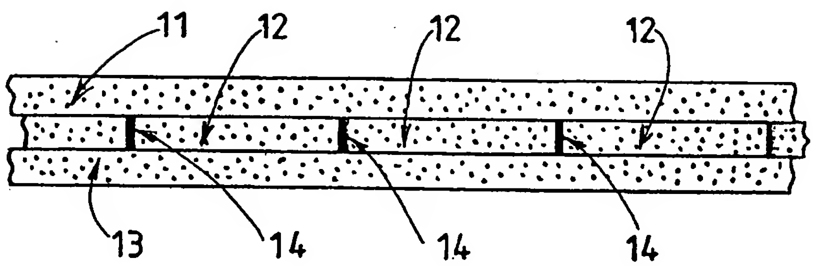

FIGURE 6.

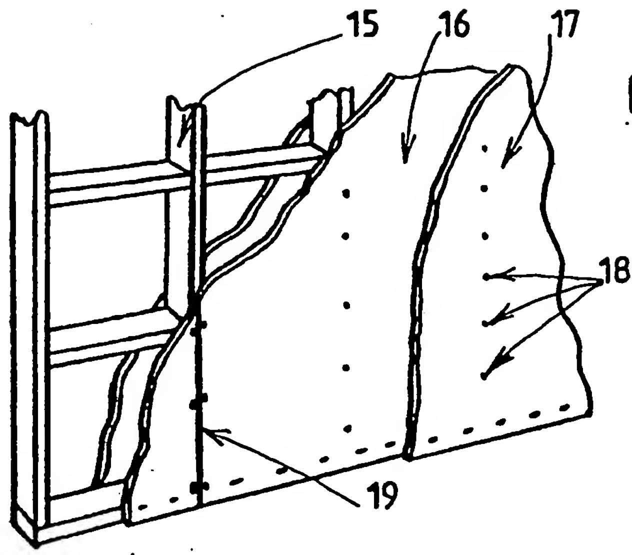

FIGURE 7.

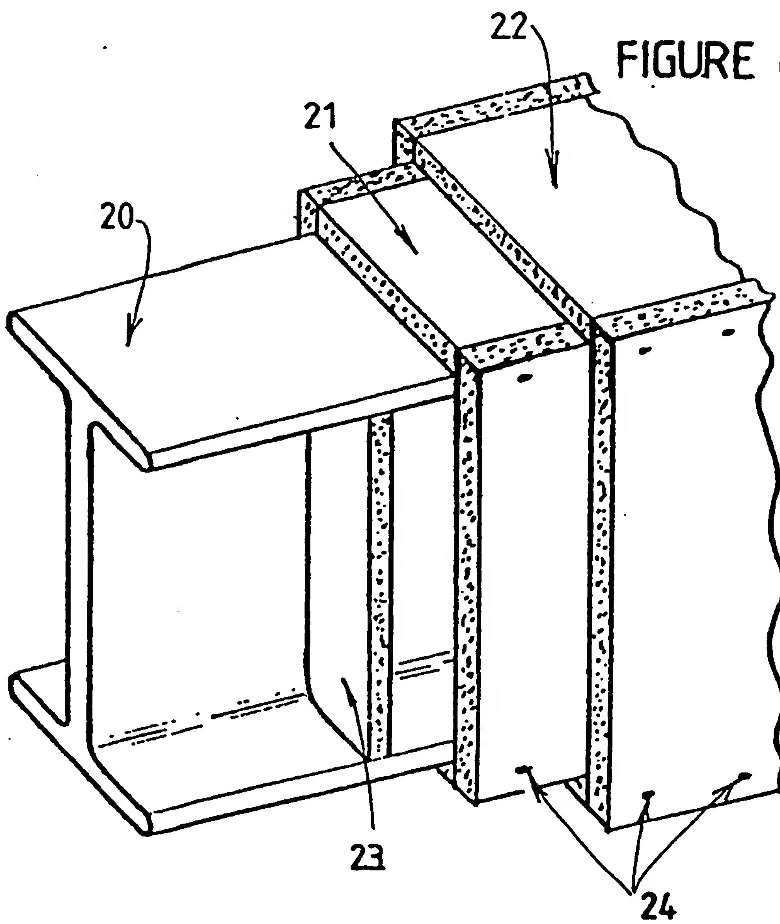

FIGURE 8.

SPECIFICATION

Fire resistant material and construction

This invention relates to material formed for use in fire resistant constructions and to said constructions.

Several prior art materials are known and intended for use in fire resistant and heat protective constructions and applications. In the past, the most effective of materials formed for use in fire resistant constructions have contained asbestos minerals, which are known to be injurous to health.

Because of the health hazards associated with mining, manufacturing and using asbestos and asbestos-containing materials, attempts have been made to produce substitutes. The most common substitutes are calcium silicate reinforced with organic fibres such as lignocellulosic kraft fibres or cotton linters for example, and sometimes including glass fibres and mica for example.

In general, the asbestos-free substitute materials are disappointing in use for various reasons. The organic fibres deteriorate causing the material to crack and fail. Additionally, the adequate strength, the materials are manufactured at relatively high density which increases the cost of installation and use and increases thermal conductivity. This is often a disadvantage.

It is an object of one aspect of this invention to provide a substantially fire resistant material.

It is a further object of one aspect of this invention to provide substantially fire resistant compositions.

Other aspects and advantages of the present invention will become apparent from the following description.

Brief summary of the present invention

According to one aspect of this invention, there is provided a substantially fire resistant material, said material including synthetic mineral fibre; selected clay and one or more binders.

According to a further aspect of this invention, there is provided a substantially fire resistant construction, said construction comprising substantially fire resistant material including synthetic mineral fibre; selected clay and one or more binders.

Brief description of the drawings

This invention will now be described by way of example only, with reference to the accompanying drawings, wherein:

Figure 1 is a weight loss curve showing the per cent weight loss of a selected clay within the temperature range 400°C - 650°C when heated.

Figure 2 is an example of the differential thermal analysis curve for a suitable selected clay, showing a strong endotherm within the temperature range 400°C - 650°C.

Figure 3 is a graph showing a relationship between density and thermal conductivity for fire resisting material made in accordance with the requirements of this invention.

Figure 4 is a graph showing temperatures in a furnace and in various positions in a fire resistant construction incorporating fire resistant material containing selected clay.

Figure 5 is a cross-section showing an example of use of fire resistant material in association with a metal member or frame.

Figure 6 is a cross-section showing an example of use of the fire resistant material in a laminated construction.

Figure 7 is a perspective view showing an example of use of the fire resistant material in association with a timber construction.

Figure 8 is a perspective view showing an example of use of the fire resistant material to protect a structural steel member.

Description of preferred embodiments

There are numerous land-based and off-shore applications where fire resistance is needed. For most important applications fire resistance is specified in terms of standard tests such as Australian Standard AS1530 Part 4, International Standards Organisation ISO 834, British Standard BS476 Part 8 for example, and numerous others. Fire resistance is usually taken to mean resistance to penetration by fire as determined by criteria defined in the various standards, and this is typically described in terms of hours of fire resistance. Fire tests which determine the reaction of surfaces of materials to fire such as Australian Standard AS1530 Part 3, and British Standard BS476 Part 7 are also bearing upon or pertinent to the invention since they are intended to test for surface propagation of flame and the generation of smoke for example which are associated fire hazards.

Fire resistant materials made in accordance with the present invention includes synthetic mineral fibre, selected clay, and binder as essential components. The material of the invention is referred to hereinafter as the fire resistant material.

The invention also envisages fire resistant constructions utilising the fire resistant material of the invention. Constructions utilising the material of the invention are referred to hereinafter as fire resistant constructions.

The fire resistant material of the present invention includes one or more mineral fibres, one or more selected clays and one or more binders.

Synthetic mineral fibres used in this invention include one or more of: glass wool, rockwool and slagwool for example, as distinct from the group of natural mineral fibre substances collectively known as asbestos. Asbestos is not included in the present fire resistant material for reason of its health hazard.

A preferred mineral fibre is rockwool, either spun, blown, drawn or otherwise attenuated; more preferably basalt wool or basalt fibre. We have found basalt fibre to be particularly useful in preparing the fire resisting material due to its relatively low cost and comparably high melting point. This is important since standard fire resistance tests require exposure at temperatures exceeding

1200°C at six hours elapsed time, while many fibres (such as E-glass for example), melt or soften substantially at temperatures lower than this, causing shrinkage and distortion.

A further essential component in the fire resistant material is one or more selected clays. The clay or clays included are selected to provide an endothermic reaction in the fire resistant material at temperatures within the range of 400°C - 650°C, such as when the material is exposed to fire and/or extreme heat. The endotherm is due to the loss of hydroxyl water from the clay mineral structure during heating and the effect can be detected and measured, for example by differential thermal analysis, or by monitoring weight loss, when a specimen of the clay is heated at a predetermined time/temperature heating rate. The specimen temperature will be found to fall below the predetermined heating rate and there will be a significant weight loss within the temperature range 400°C - 650°C with suitable clay. An endotherm and weight loss also takes place at temperatures of about 100°C where absorbed water is lost from most clays, but many clays do not exhibit the endotherm and weight loss within the temperature range 400°C - 650°C which is essential in the selected clays for use in the fire resistant material.

Differential thermal analysis of clays is discussed in the publication (*"Applied Clay Minerology" Author R.E. Grum, published by McGraw-Hill book company*); particularly in Chapter 3, "Clays in Ceramic Products". Differential thermal analysis curves of both suitable and unsuitable clays can be found in this publication.

In order to identify clay suitable for use in the fire resistant material of the invention, a simple apparatus may be assembled, for example consisting of a mass determining means from which a wire or rod is suspended to a sample holder, (such as a crucible adapted to hold a clay sample), and a heating means to heat the clay contained in the crucible. The arrangement is such that the clay sample may be heated at a substantially predetermined heating rate while the mass of the clay sample is monitored. Preferably, before testing the clay is dried to constant weight at between 100°C and 125°C, to remove absorbed water, after which a sample is accurately weighed for use in the test.

When tested in accordance with the method described, pre-dried clay suitable for use in the invention will show a weight loss of at least 4% in the temperature range 400°C - 650°C. A weight loss of 8% or more may be found with more suitable clay. A typical weight loss curve is shown in Figure 1. There is an initial weight loss as absorbed water is released by pre-drying followed by a rapid weight loss at temperatures within the range 400°C - 650°C with suitable clay as shown in Figure 1.

To further illustrate the characteristics of a suitable clay a typical differential thermal analysis curve is shown in Figure 2 where the strong endotherm at temperatures within the range 400°C - 650°C can be clearly seen.

Although not intended to limit the invention in any way, a suitable predetermined heating rate for use in testing for clay suitability is between 5°C and 15°C per minute. This heating rate allows ample time for reactions to take place and for changes in weight of the sample to be observed.

With further reference to the weight loss test described herein it should be noted that some clays contain appreciable amounts of pyrites such as iron pyrites, and the oxidation of these sulphides can also give a weight loss in the temperature range of interest. The oxidation of sulphieds is exothermic making pyrites-bearing clays entirely unsuitable for the purposes of the invention.

Many hydrous silicate clay minerals which exhibit a significant endotherm within the temperature range 400°C - 650°C are suitable for use in the fire resistant material and these include hydrous silicates of aluminium, calcium, magnesium and sodium for example. Of these the hydrous aluminium silicate clays and clay minerals are most advantageous, including Kaolinite, Nacrite Dickite, Halloysite, Montmorillonite, Beidellite, Pryophyllite, and Allophane, when the particular specimens exhibit a significant endotherm within the temperature range 400°C - 650°C as previously described. Any suitable clay which exhibits this endotherm may be used and the list of clays given above, is by way of example only.

The binder used in preparing the fire resisting material may be of any suitable type, either organic or inorganic; such as starches and modified starches; condensates of phenol, urea, melamine, resorcinol, tannin and the like with aldehyde; isocyanates, reactive cements such as magnesia cements; binders formed in situ by inter-reaction between silica and calcium; hydraulic cements which set by hydration; potassium and sodium silicates, and/or, for example, combinations of these binders.

Preferred binders include starches, modified starches, and cross-linked starches; and condensates of phenol, urea, and malamine, with aldehydes.

Other binders may however be used to advantage.

In one form of the invention a composition of the fire resistant material is:

45% - 70% (by weight) - Synthetic Mineral Fibre
27% - 52% (by weight) - Selected Clay
3% - 28% (by weight) - Binder

In a further form of the invention the fire resistant material, composition of the material is:

55% - 68% (by weight) - Synthetic Mineral Fibre
29% - 38% (by weight) - Selected Clay
3% - 16% (by weight) - Binder

Optionally, the fire resistant material may also contain minor amounts, up to 8%, of the total weight of components selected from micra, wood fibre, expanded perlite, glass fibre, polypropylene fibre, or combinations of these minerals. The fire resisting material may also contain minor amounts of other compounds apart from the essential components as described hereinbefore.

It should be appreciated that the fire resistant material may include one or more, (ie: a plurality), of the necessary synthetic mineral fibre; selected

clay and binder.

The fire resistant material may be manufactured by either a conventional dry-forming process, or a wet-forming process involving de-watering from an aqueous slurry. In either case the ingredients are first suspended in a fluid such as gases or liquids followed by separation on a screen, the fluid or a proportion thereof passing through said screen to leave a mat or solids which is subsequently pressed and/or dried to produce the product, and/or cure or set the binder.

In a wet-forming process additives may be included to aid flocculation, and in any case sizing agent such as wax, rosin, or silicone for example may be included. Other sizing, bonding or property improving agents may also be included.

A preferred density range for the fire resistant material, especially when manufactured in sheet or panel form, is 320 kg per metre^3 to 500 kg per metre^3. It has been found desirable to keep density as low as practicable consistent with strength. Especially this is so, as the utility of the material, (especially in such applications as doors) is improved by a reduction in weight, in comparison with many prior art fire resistant materials. The fire resistant material may also be manufactured in the form of bricks, slabs, moulded bodies or any other desired or appropriate form.

A further preferred density range for the fire resistant material is 330 kg per metre^3 to 420 kg per metre^3.

The relationship between density and apparent thermal conductivity of the fire resisting material is shown in Figure 3 of the drawings, as determined using a Dynatech Rapid K thermal conductivity instrument.

The fire resistant material having a composition as described herein has also been tested by exposure to the standard time/temperature curve shown in illustration (Figure) 4 (a) of Australian Standard 1530, Part 4-1975: "Fire Resistance Tests of Structures". The results of the tests are shown in Figure 4 herein, where the advantage of the selected clay and its associated endotherm can be clearly seen. The results were obtained by exposing one side of a specimen construction in a furnace operating in accordance with the requirements of AS1530, Part 4-1975 which is similar to ISO 834-1975 and BS476 Part 8-1972, all being well recognised fire resistance tests.

The specimen construction tested consisted of two layers of the fire resistant material as described herein laminated together using a laminating cement (to be described further herein) fastened each side of an internal mild steel metal frame. The laminated layers were fastened to the metal frame using self-tapping steel screws. The individual layers were 14mm thick, giving 28mm each side of the metal frame. A cavity as defined by the internal frame existed between the laminated layers. Thermocouples were fitted to monitor temperatures of the furnace atmosphere, the interface at the laminating cement between the layers on the exposed side of the specimen, the cavity defined by the internal frame, and the unexposed face. The endotherm produced by the clay actually causes the temperature of the unexposed face of the specimen to fall during the test as indicated in Figure 4 of the drawings.

The fire resistant material may be used in a wide range of constructions intended to control fire, such as walls and partitions, protection to steel sections and structures both on and off shore, plant and equipment, domestic heat screens in proximity to stoves and heaters, doors, engine rooms, and boiler houses, these uses being by way of example only and not intended to be limiting in any way.

Constructions may be assembled with adhesive and/or mechanical fastenings. Any suitable laminating adhesive may be used, such as phenol-formaldehyde, urea-formaldehyde, resorcinol-formaldehyde, mealmine-formaldehyde, condensates, or various mineral cements such as magnesia or silicate cements for example.

A suitable laminating cement may be made for example including potassium or sodium silicate and silicious clay. Such cement may also include water retention aids such as water soluble gums, for example methylcellulose or a starch such as a modified starch and various viscosity control and/or dispersing agents. We have found that such an adhesive is inexpensive and particularly effective since it forms a durable bond without the application of heat. This is a significant advantage when laminating heat insulating material in that it avoids the need for slow cycles in a hot press when heat may otherwise have to penetrate through such material to set or cure internal glue lines. The fire resistant material is a heat insulating material. An advantage of the silicious clay is that during exposure of a construction to fire silica is available for reaction with potassium or sodium silicate in the laminating cement to raise the melting point of the cement during the actual fire exposure. The sodium or potassium silicate reacts with the more refractory silicious components in the clay to maintain the integrity of a fire resistant construction during a fire exposure. We have found that this cement produces reliable durable bonds in laminating the fire resistant material and it is therefore particularly useful in the manufacture of laminated constructions such as doors or partitions. We have tested such laminated constructions which have been subjected to exposure to fire in accordance with the standard time/temperature criteria prescribed in various standard fire resistant tests without failure. Indeed the laminated constructions were able to withstand a standard fire resistance test exposure for over 4 hours elapsed time, followed by the thermal shock of cooling without failure. The test specimens were removed from the furnace after the test and remained intact, which is most unusual.

The fire resistant material may also be used to assemble fire resistant constructions using mechanical fastenings such as bolts screws or nails for example. We have found self tapping steel screws suitable for fastening such material to steel frames for example, and have conducted success-

ful tests where steel nails have been used to fasten the fire resistant material to timber wall and partition frames. While austenitic heat resistant grades of steel may be used for fastenings edge stiffeners and internal members of fire resistant constructions, we have found that common mild steel is satisfactory for most purposes.

Specimen fire resistant constructions were also tested in the form of three layer laminates and door constructions with internal frame and sheathings, including aluminium sheathing. Three layer laminates in which the centre layer was in the form of strips with mild steel stiffening members therebetween were also tested successfully.

It is envisaged that the fire resistant constructions may be fitted with any suitable facings or sheathings to provide protection and/or decoration and the sheathings or facings may be either adhesive laminated to faces or in utility constructions pop-riveted or screwed for example to a subframe.

We have also tested fire resistant constructions wherein folded metal angle stiffeners were provided at specimen edges for the purpose of providing strength, stiffness and stability both in service of the construction such as a door and when exposed to fire. Internal frames and/or edge stiffeners were also found useful in providing members from which doors could be suspended for example, for connecting partition members together for example, or to provide fixing points for hinges and/or locks for example.

Fabricated constructions incorporating the fire resistant material were also tested successfully wherein the fire resistant material was fastened to an internal timber frame as used in wall and partition constructions. Nail fasteners were used in this case.

The fire resistant material is found to have desirable properties when the reaction of its surface to fire is evaluated in accordance with standard tests such as BS 476 Part 7 and AS1530 Part 3. A Class I Spread of Flame is obtained when tested in accordance with BS476 Part 7. Indices of: Ignitability 0: Heat Evolved 0; Spread of Flame 0; and Smoke Developed 0; can be obtained when tested in accordance with AS1530 Part 3.

In one form of the invention decorative sheets such as paper or plastic film overlay either resin impregnated and hot pressed or adhesive applied may be provided as a surface to the fire resistant material.

In another form of the invention the fire resistant material may be provided with a core and face layers wherein the core and face layers differ in composition and/or density within the limits described hereinbefore.

With reference to Figure 5, fire resistant material is fastened each side of an internal metal frame member (1). The frame member may be a common hollow section as shown, or may for example be roll formed sheet as required. Suitable fastenings (2) and (3) such as self tapping screws or pop rivets for example may be used to fasten the fire resistant material to the internal metal frame. The internal metal frame may be any suitable section, usually of mild steel, to function for example as a stud in a wall or partition, or as part of an internal frame assembly in a door for example. Two layers of fire resistant material (4 and 5) and (6 and 7) are shown each side of the internal metal frame, the number of layers and thickness being selected to suit the fire resistance required. A cavity (8), defined by the thickness of the metal frame may also be present, the cavity being either left void as shown, or filled with an insulant such as spray applied mineral wool (such as basalt wool) or mineral wool blanket for example. At the interfaces (9) and (10) between the layers an adhesive may be applied to laminate the layers together.

Constructions similar to those shown in Figure 5 will produce doors and partitions with a fire resistance of 4 hours or more as required.

With reference now to Figure 6 we show a laminated construction employing the fire resistant material. Laminated constructions have been found useful in such applications as small doors, partitions, and to produce heat and fire resistant elements for use in industry, kilns, engine rooms and the like. In Figure 6 three layers are shown (11) (12) and (13), but any number of layers may be used. In Figure 6 the centre layer (12) is shown in the form of strips with metal reinforcing sections (14) placed between the strips at the time of laminating. The reinforcing sections (14) are shown by way of example only as they are not essential. They have however been found to contribute to strength and stability in a fire when the laminated constructions are used in the form of small fire doors for example. A suitable adhesive such as that described hereinbefore based upon sodium or potassium silicate and a silicious clay may be used to laminate the layers together. Laminated constructions similar to the example shown in Figure 6 can be used to produce assemblies with fire resistance of two hours or more when tested in accordance with standard fire resistance tests.

Referring to Figure 7 we show an example of use of the fire resistant material in association with timber construction. A timber frame construction (15) has the fire resistant material applied in one or more layers (16) and (17). Common wire nails or other suitable fastenings (18) may be used to fasten the materials to the timber frame, and the individual sheets may be butt jointed (19) over the timber frame elements as necessary. We have obtained fire resistances of two and three hours using this type of construction. Figure 7 serves to illustrate the protection of timber construction against fire using the fire resistant material.

Referring now to Figure 8 we show an example of the use of the fire resisting material to protect structural steel. A structural steel member (20) is encased using a box construction of the fire resistant material (21). Depending upon the thickness of the fire resistant material used, and the fire-resistance required, further layers, for example (22) may be added. Depending upon the shape or section of the structural steel member, support gussets (23) may be cut and fitted to provide extra support for

the main fire resistant sheets. The gussets (23) may be cut from the fire resistant material, which is easily marked. The fire resistant material may be secured with adhesive, and for convenience, conventional fastenings such as nails or staples (24) may be used to assist in the assembly. The fire resistant material may be used to protect various structural steel sections as well as flat plates such as ships bulkheads and engineroom firewalls in this way. As a general guide 18mm of the fire resistant material will provide at least three hours fire resistance to steelwork and 21mm will provide at least four hours fire resistance.

The invention is not limited to the embodiments described herein other than that the fire resistant material contains as essential components, one or more synthetic mineral fibre(s); selected clay(s); and binders(s). The embodiments are provided to illustrate the invention by way of example only and various versions or modifications to both the fire resistant material and the fire resistant constructions will become apparent to those skilled in the art and are therefore included within the scope of the invention as defined by the appended claims.

The invention provides a useful fire resistant material which is asbestos free and which by virtue of the presence of selected clay enables fire resistant constructions to be assembled, which heat on an unexposed face at a lower rate than would normally be expected when the material's thermal conductivity is taken into account. The lower heating rate provides additional fire protection and a higher fire resistance rating in terms of standard fire resistance tests, than materials presently known and available.

It should be appreciated that this invention has been described by way of example only, and that modifications and improvements may be made, without departing from the scope thereof.

CLAIMS

1. A fire resistant material including one or more synthetic mineral fibres; one or more selected clays and one or more binders.

2. A material as claimed in claim 1 wherein the synthetic mineral fibres include glass wool; rock wool and slag wool.

3. A material as claimed in claim 1 or claim 2, wherein the synthetic mineral fibre includes basalt wool and/or basalt fibre.

4. A material as claimed in any one of the preceding claims wherein said clay exhibits an endothermic reaction in said fire resistant material, at temperatures within the range of approximately 400°C to approximately 650°C.

5. A material as claimed in any one of the preceding claims, wherein a selected clay exhibits a weight loss of at least 4% when subjected to heat in the temperature range of 400°C to 650°C.

6. A material as claimed in claim 5, wherein the clay is heated at a predetermined rate of between 5°C and 15°C per minute.

7. A material as claimed in any one of the preceding claims wherein the clay includes hydrous silicate clay.

8. A material as claimed in any one of the preceding claims wherein said clay includes hydrous silicate clay minerals.

9. A material as claimed in any one of the preceding claims, wherein the clay includes one or more hydrous silicates of aluminium, calcium, magnesium and sodium.

10. A material as claimed in claim 1, wherein the clay includes one or more of Kaolinite; Nacrite; Dickite; Halloysite; Montmorillonite; Beidellite; Pyrophilite and Allophane.

11. A material as claimed in any one of the preceding claims, wherein said one or more binders include organic or inorganic binders.

12. A material as claimed in any one of the preceding claims, wherein said binder(s) includes starches; modified starches; cross-linked starches; and condensates of phenol, urea, melamine, with aldehydes.

13. A material as claimed in any one of the preceding claims including up to 8% by weight, of mica; wood fibre; expanded perlite; glass fibre; polypropylene fibre, or combinations thereof.

14. A material as claimed in any one of the preceding claims, including:
45% - 70% (by weight) - Synthetic Mineral Fibre
27% - 52% (by weight) - Selected Clay
3% - 28% (by weight) - Binder.

15. A material as claimed in any one of the preceding claims, including:
55% - 68% (by weight) - Synthetic Mineral Fibre
29% - 38% (by weight) - Selected Clay
3% - 16% (by weight) - Binder.

16. A material as claimed in any one of the preceding claims, having a density of 320 kg per metre^3 to 500 kg per metre^3.

17. A material as claimed in any one of the preceding claims having a density of between 330 kg per metre^3 to 420 kg metre^3.

18. A fire resistant construction including substantially fire resistant material as claimed in any one of the preceding claims.

19. A fire resistant construction, including substantially fire resistant material comprising synthetic mineral fibres, selected clay and one or more binders.

20. A fire resistant material substantially as hereinbefore described with reference to Figures 1 to 4 of the accompanying drawings.

21. A fire resistant construction substantially as hereinbefore described with reference to Figures 5 to 8 of the accompanying drawings.

Printed in the UK for HMSO, D8818935, 3/86, 7102.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.